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Q2S

Colonel Blotto in the Phishing War

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Outline

- Background
  - Phishing
  - Colonel Blotto
- Modeling : Colonel Blotto Phishing game
- Analysis
- Implications to Anti-Phishing

Background

Background:
Phishing

- Annual Phishing losses?
  - $15.6 billion in identity theft loss [FTC 2006]
  - $3.2 billion in phishing loss [Gartner 2007]
  - $61 million (with ~0.2% actual victim rate, $200 median loss) [8]
- Characteristics:
  - ~30,000 phishing domains per 6-month [APWG]
  - Weak vs. strong phisher (e.g., Rock-Phish & Avalanche)
  - Different ways to host a phish (e.g., compromised servers, free-hosting services)
  - Can be hard to take down (e.g., Rock-Phish & Avalanche use fast-flux IP switching)
  - Not all phishes detected (information asymmetry)
- Q: What is the optimal strategy of a phisher?

Colonel Blotto game

- 2-player constant-sum
- Allocation of finite resources in *n* battlefields
- Borel (1921)
- Borel and Ville (1938) : symmetric resources, *n*=3
- Gross and Wagner (1950) : asymmetric resources, but solved *n=2* only

  .. [complex, lack of pure strategies] ..

- Roberson (2006) : characterization of unique equilibrium payoff

Background: Colonel Blotto game

Application to Security?

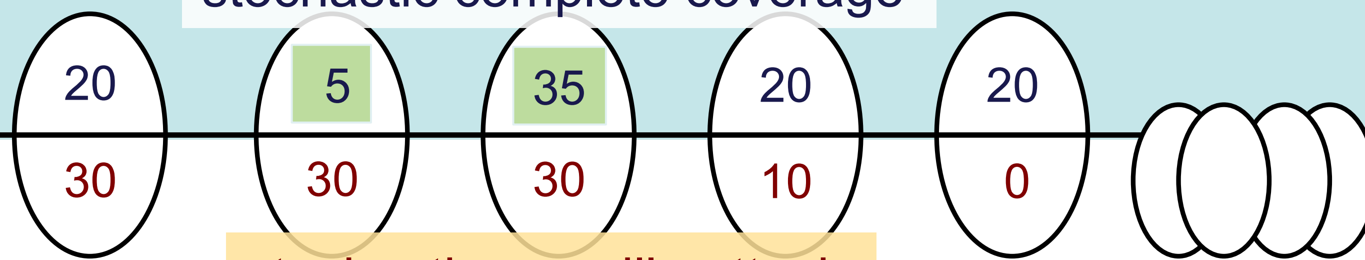
Information asymmetry?

Colonel Blotto:

Limited resource = 100 soldiers

stochastic complete coverage

n=5



stochastic guerrilla attack

Attacker:

Symmetrical resource = 100

Asymmetrical resource < 20 (trivial)

Asymmetrical resource > 20 (complex!)

Kovenock et al. (2010):
- endogenous dimensionality

Roberson (2006):
- payoff w.r.t. resource asymmetry

Modeling : Colonel Blotto Phishing (CBP)

Colonel Blotto Phishing game

- Player: takedown company vs. phisher
- Battlefield: a phish
- Objective: maximize (minimize) fraction of phishes with more than a certain uptime
- Resource: infrastructure, manpower, time (finite) (use it or lose it) (defender has more resources)
- Cost: low: use a free-hosting service
  medium: register a new domain
  high: compromise a server

- Stage: (1) create – detect
  (2) resist – takedown
- Can phisher win in a detected battlefield?
  - No, if phisher's resource is much lower (total lock-down)
  - Yes, if phish survives a certain uptime
    - Not resolving phish URL at every access, or temporarily removing a phish [6]
    - Re-compromising a vulnerable server [7]
    - Fast-flux IP switching (e.g., by Rock-Phish & Avalanche)

Phisher: How many new phishes to create?

S1

$$\max_{n_w} E(U_w|n_w) = \frac{1}{n} E(\sum_{j \in \mathbb{J}_d} \pi_{w,j}) + \frac{(1-P_d)n_w}{n} - cn_w$$

$$= \underbrace{\frac{n_d}{n} E(\pi_w)}_{\text{detected phishes}} + \underbrace{\frac{(1-P_d)n_w}{n}}_{\text{undetected phishes}} - \underbrace{cn_w}_{\text{cost}}$$

S2

$$E(\pi_w) = \begin{cases} \frac{R_w}{2R_s} & \text{if} \quad 1 \geq \frac{R_w}{R_s} \geq \frac{2}{n_d} \\ \frac{2}{n_d} - \frac{2R_s}{(n_d)^2 R_w} & \text{if} \quad \frac{2}{n_d} \geq \frac{R_w}{R_s} \geq \frac{1}{n_d - 1} \\ 0 & \text{if} \quad \frac{1}{n_d} \geq \frac{R_w}{R_s} \end{cases}$$

Roberson (2006)

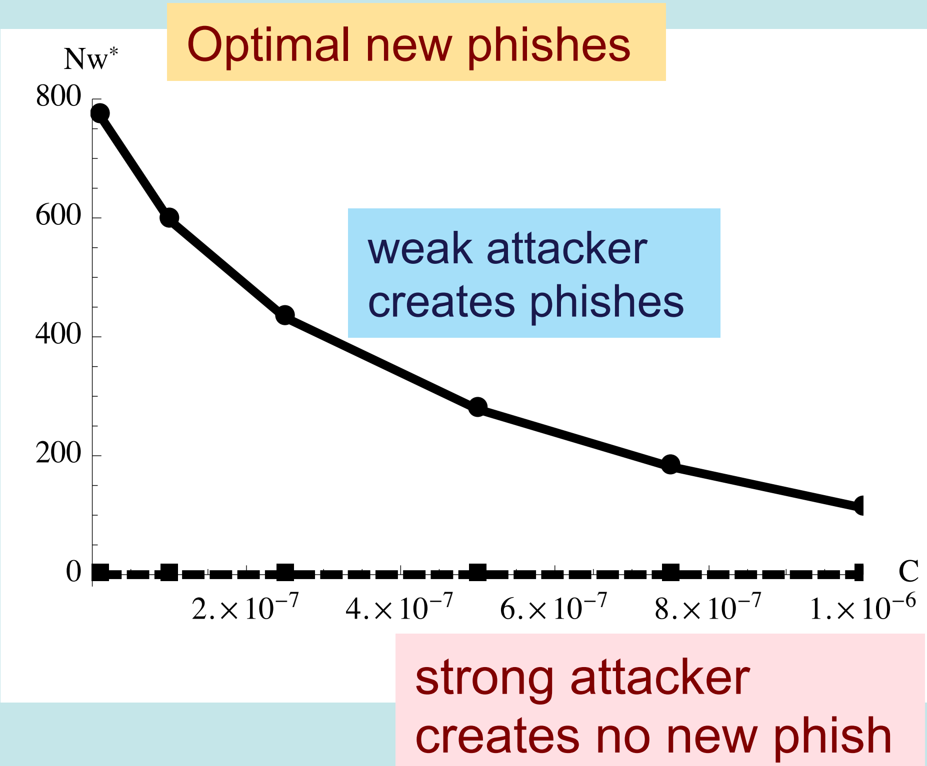
$$n_d = P_d n_w + n_0$$

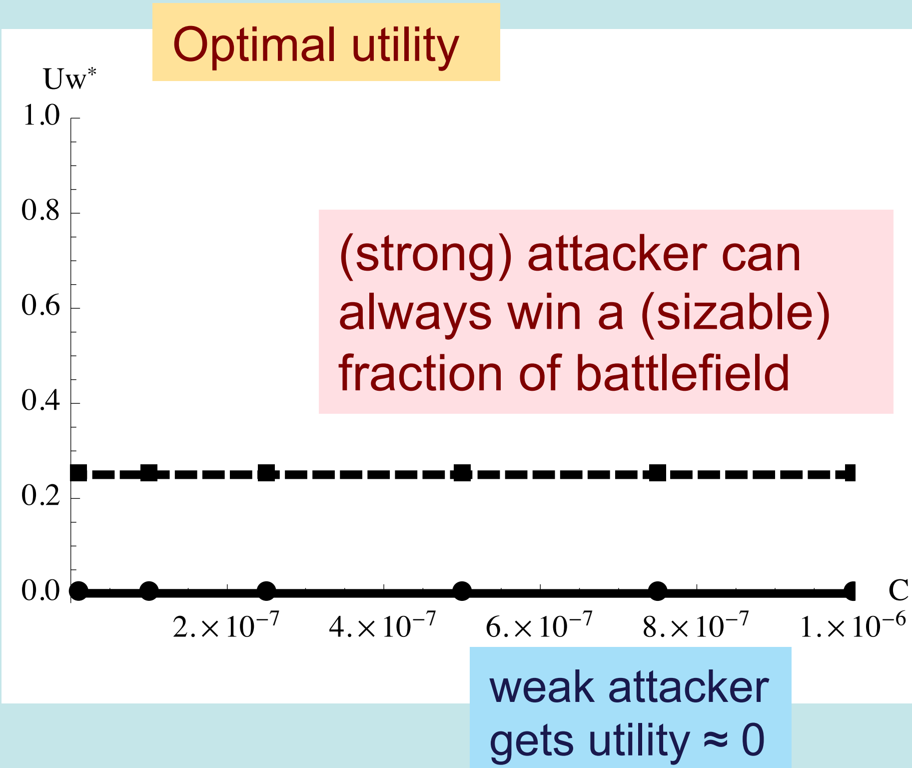
$$n = n_w + n_0$$

Analysis Results

Phisher's strategy C1:

Perfect Detection (same settings as in [4])





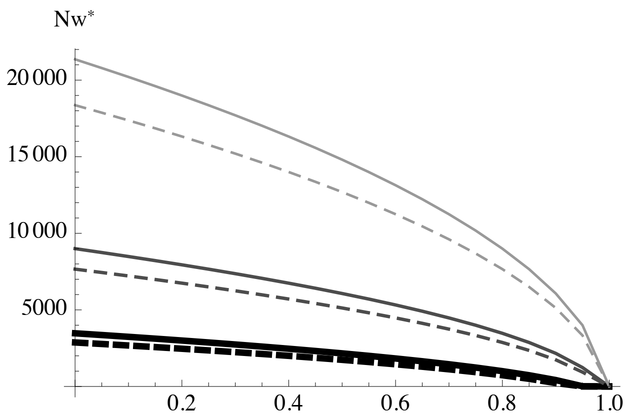
- Resource asymmetry: strong attacker vs. defender = 1/2

  weak attacker vs. defender = 1/900

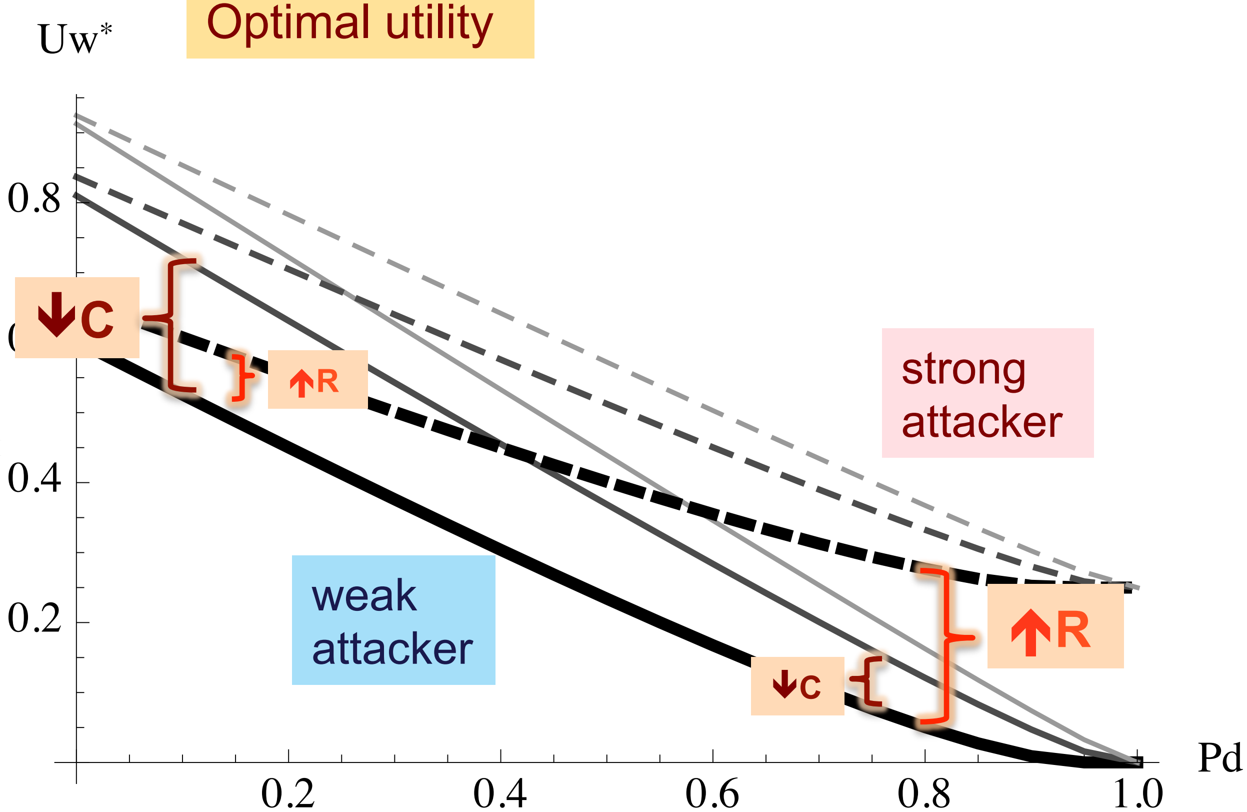
Phisher's strategy C2:

Imperfect Detection (exogenous)

Optimal new phishes



Optimal utility



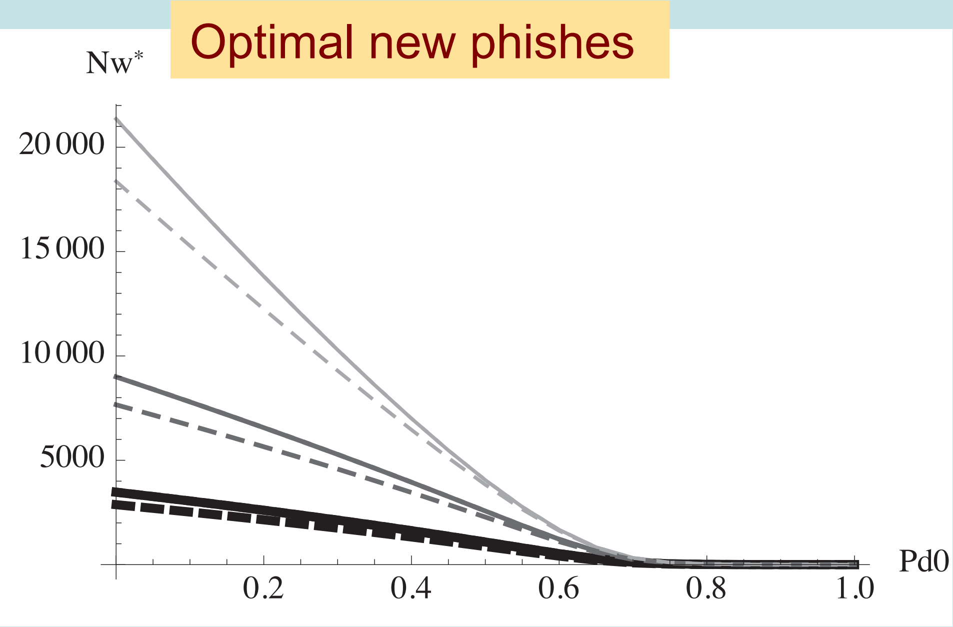
- Weak attacker creates more new phishes
- Weak attacker hurts more as Pd increases

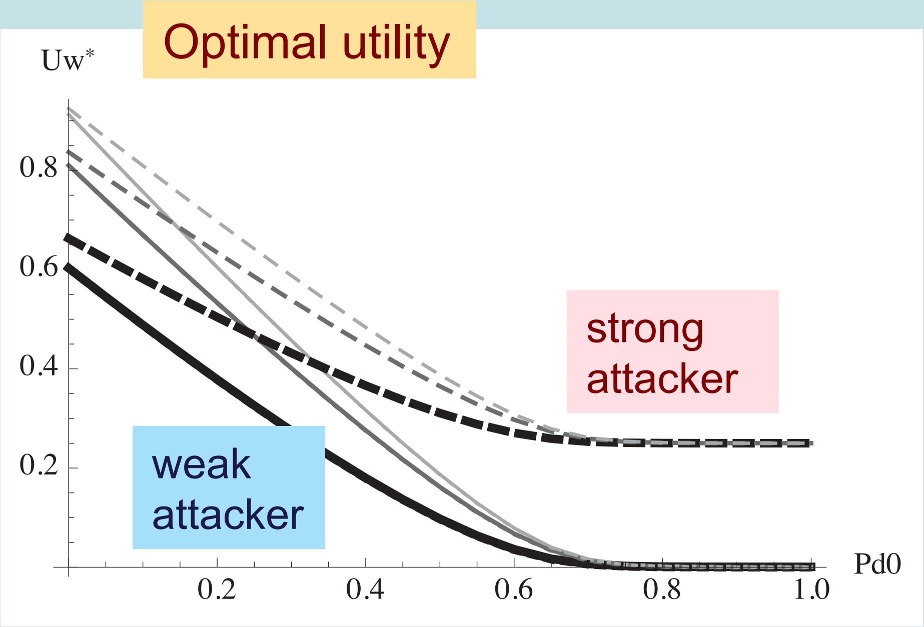
  better off, if Pd ➔ 1: improve resources to resist takedown

  if Pd ➔ 0: lower cost to create more phishes

Phisher’s strategy C3:

Imperfect Detection (endogenous)





- If new phishes increase detection rate
  - Registrars look for suspicious domain registration pattern [6]
  - ‘Rock Phish’ and ‘Avalanche’ phishes hosted on same domain [APWG]
- Less phishes and utility

Discussion & Summary

Implications to Anti-Phishing Industry

- Increasing cost of a phish
  - Affect a weak attacker more
  - But can use stolen credit cards, or ‘easy’ domains (e.g., .tk, co.cc) [6]
  - 80% attacks used compromised servers [6,7]
- Improving detection rate
  - Concerns for sharing among takedown companies
  - User reporting (not necessarily requiring user evaluation) can be helpful
- Empirical estimation & prioritizing
  - Pd ➔ 0: make phishing cost higher
  - Pd ➔ 1: disrupt resources (e.g., access to botnet, underground market)

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Summary

- Colonel Blotto Phishing (CBP)
  - Resource asymmetry
  - Information asymmetry
  - Endogenous dimensionality
- Applicability to web security problems
  - Two-step detect & takedown process
- Extensions
  - Competition between phishers -- Tragedy of the Commons? [8]

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Thank you. Questions?

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